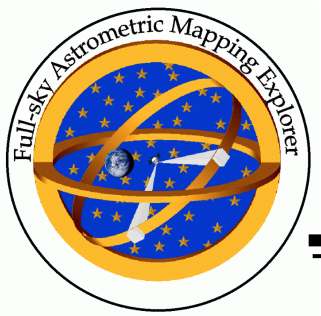
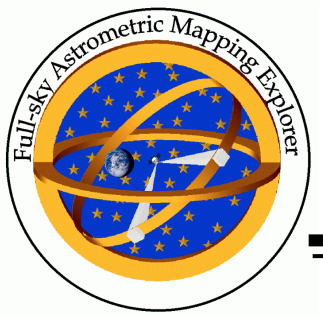


LOCKHEED MARTIN

Optical Thermal Mechanical Model

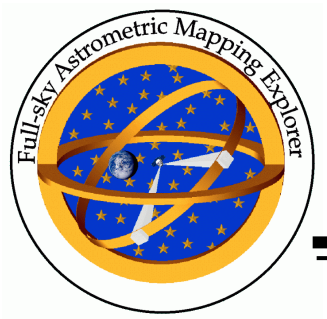
Jay Ambrose

FAME TIM
LMMS Advanced Technology Center
Palo Alto, CA
October 25-26, 2000



Topics

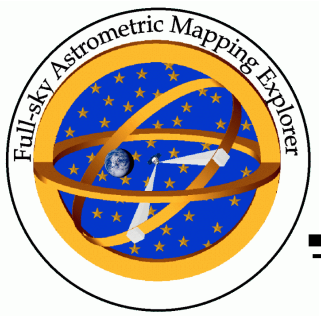
- Optical Thermal Mechanical Model Status
- Overall Instrument Thermal Design Status
- Sunshield Blanket - Is it Needed?



LOCKHEED MARTIN

OTM Model Objectives

- Support flowdown of instrument optical performance requirements to thermal gradient/stability requirements on individual components and bench structure
  - Requires facsimile of detailed thermal control scheme
  - Evolve robust thermal design approach in parallel



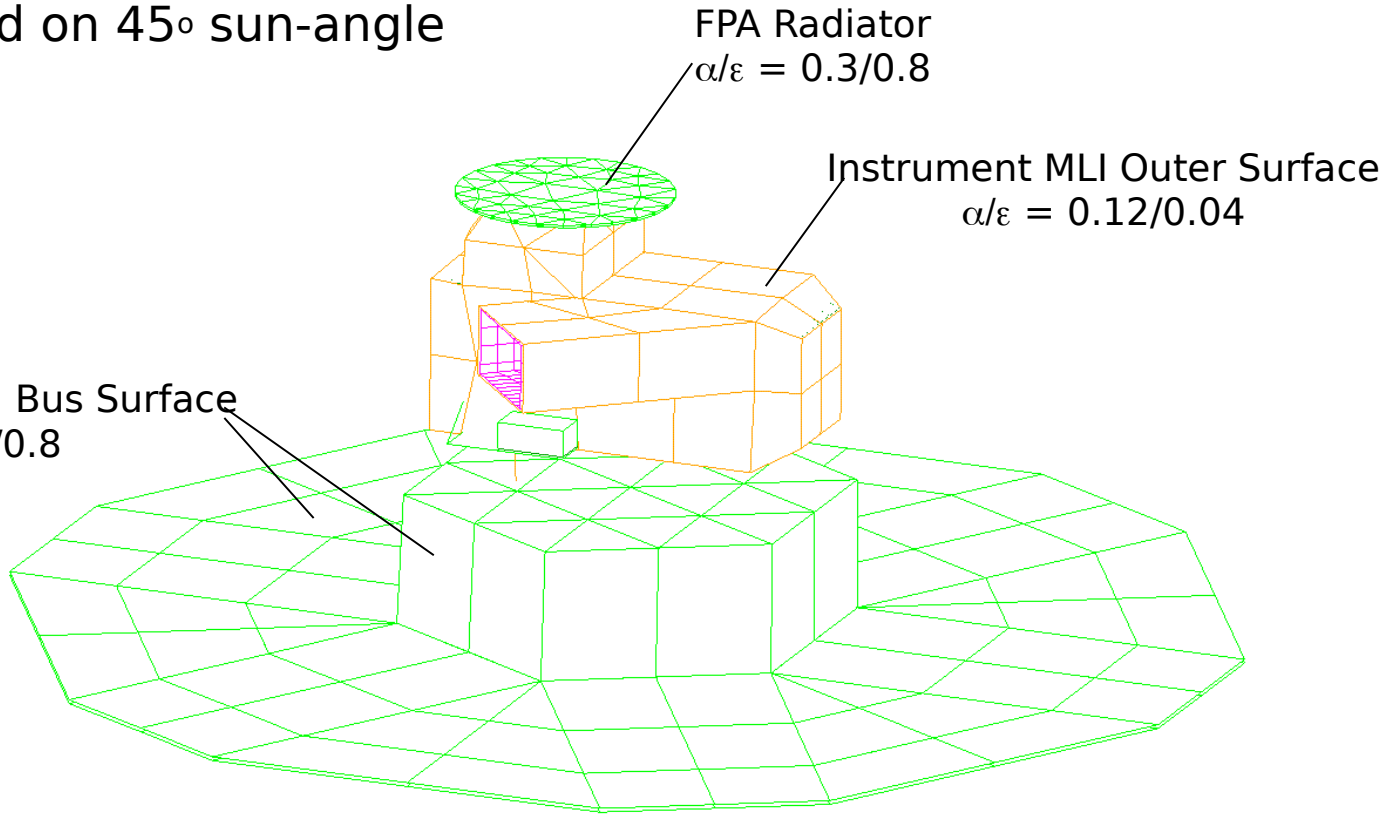
Approach

- Simplified TMG and TSS models developed to support thermal design analysis cases
- Evaluate transient orbital heating effects
- Assess preliminary heater power requirements for new instrument layout
- Develop detailed thermal model from IDEAS OTM FEM by Larry Sokolsky

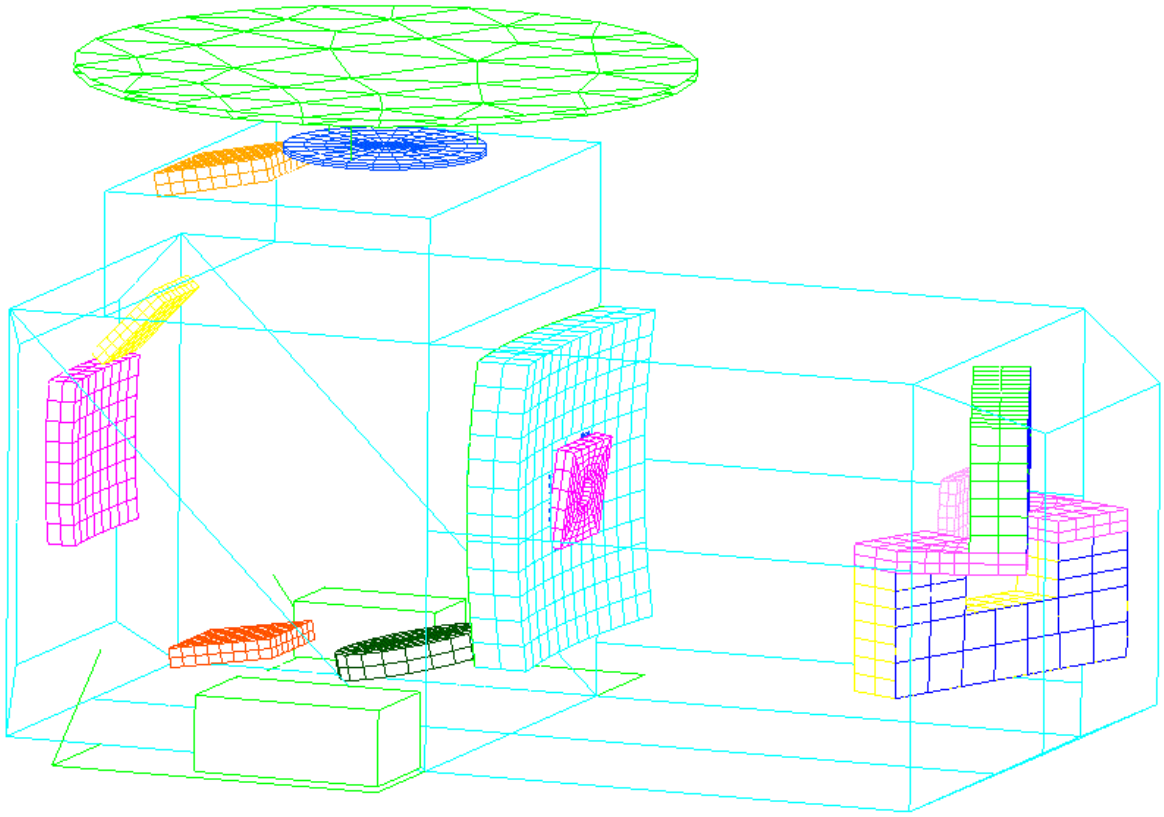
OTM Thermal Model

External Thermal Model

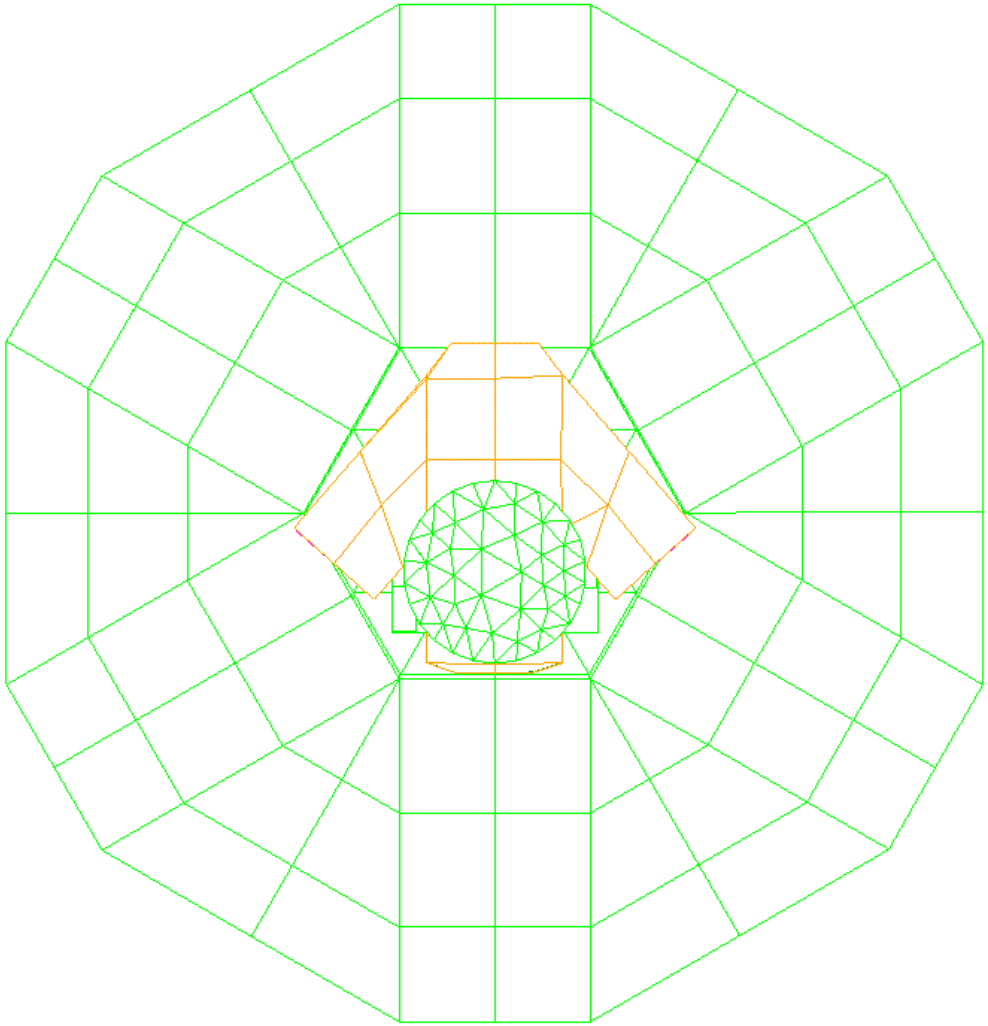
Sunshield based on 45° sun-angle

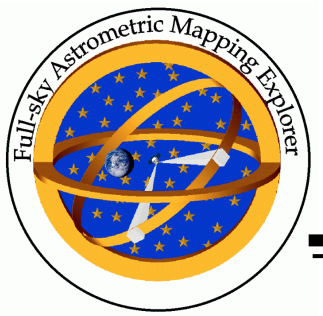


OTM Thermal Model



OTM Thermal Model



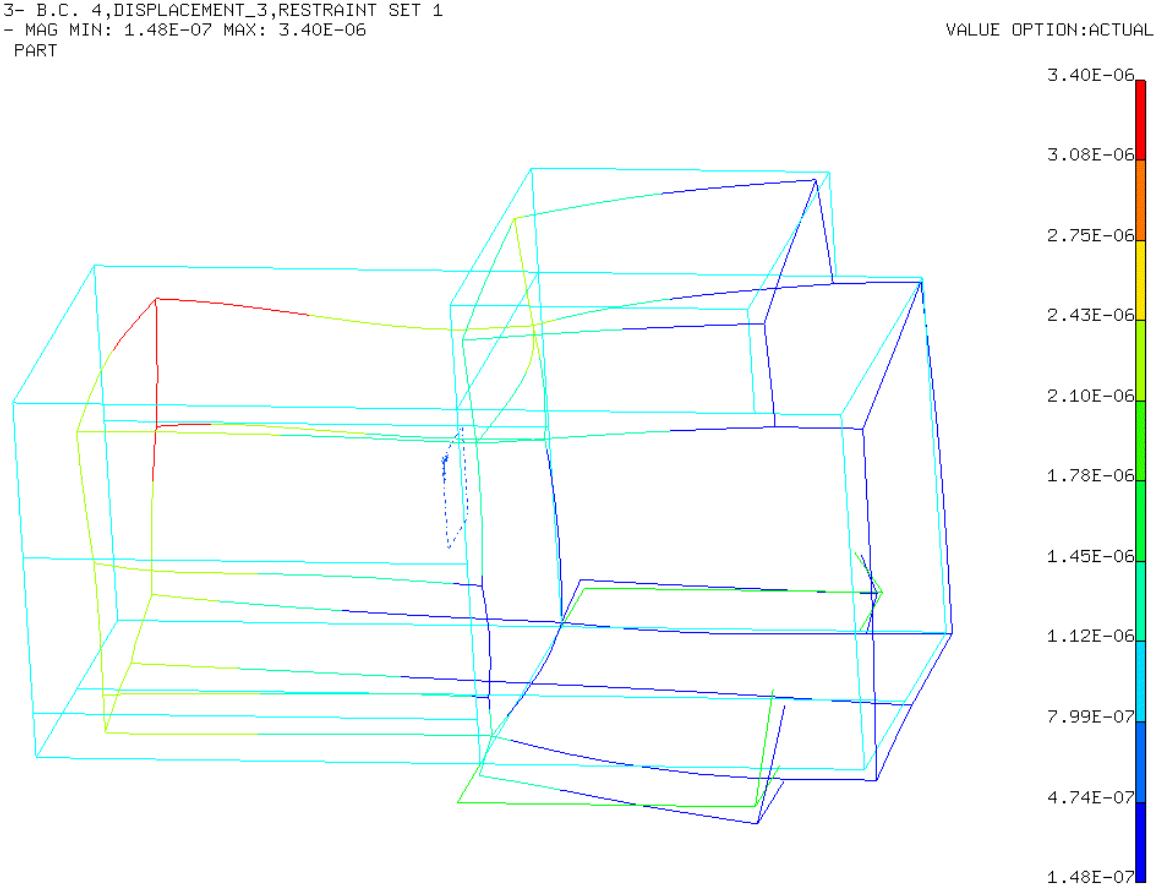


OTM Model Status

- Preliminary thermal results obtained and fed into structural analysis
- ‘Place-holder’ displacements calculated for closing loop (not checked out yet)
- Meetings held to discuss handoff of results to ray-tracing analysis by Optics group
- Expect several iterations to allow refinement of thermal/structural design for better instrument performance

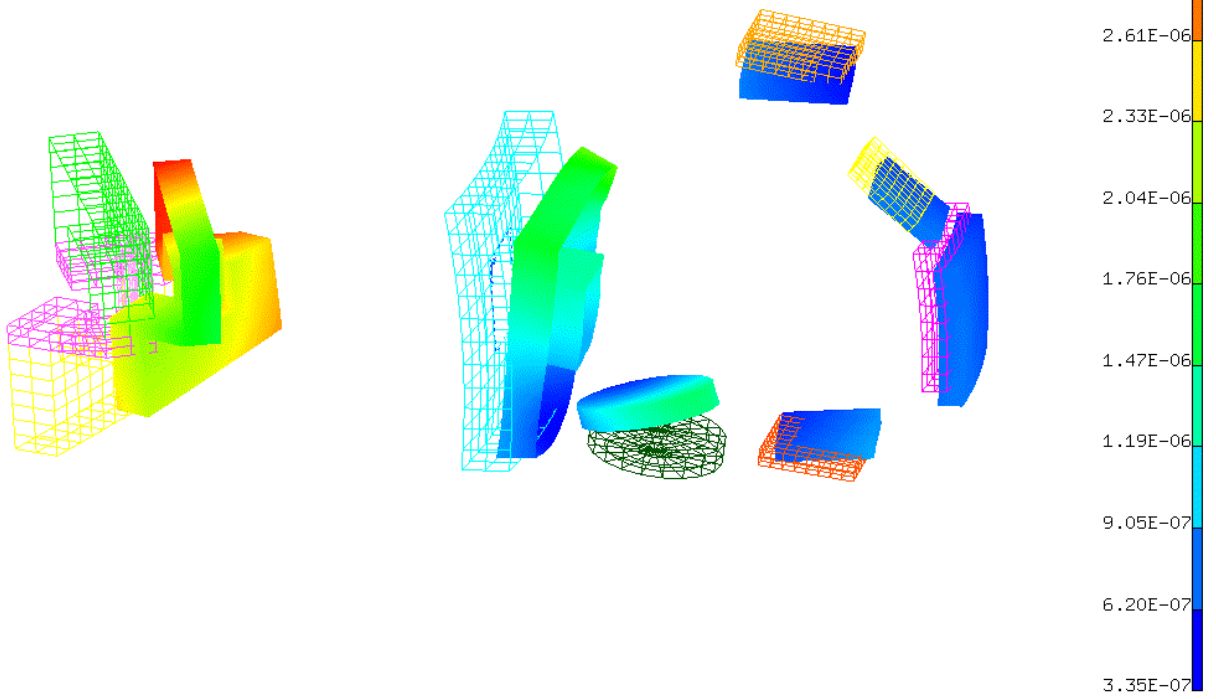
Preliminary Displacement Calculation - Optical Bench

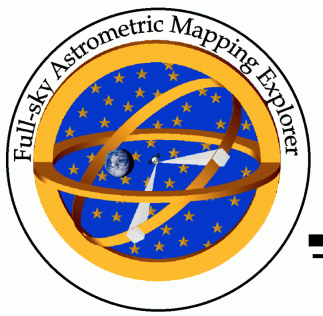
RESULTS: 3- B.C. 4,DISPLACEMENT_3,RESTRAINT SET 1
DISPLACEMENT - MAG MIN: 1.48E-07 MAX: 3.40E-06
DEFORMATION: 3- B.C. 4,DISPLACEMENT_3,RESTRAINT SET 1
DISPLACEMENT - MAG MIN: 1.48E-07 MAX: 3.40E-06
FRAME OF REF: PART



Preliminary Displacement Calculation - Optics

RESULTS: 3- B.C. 4,DISPLACEMENT_3,RESTRAINT SET 1
DISPLACEMENT - MAG MIN: 3.35E-07 MAX: 3.18E-06
DEFORMATION: 3- B.C. 4,DISPLACEMENT_3,RESTRAINT SET 1
DISPLACEMENT - MAG MIN: 3.35E-07 MAX: 3.18E-06
FRAME OF REF: PART





Orbit Heating - Simplified Models

Simplified models used to facilitate rapid evaluation of thermal design features

Single Orbit Point-

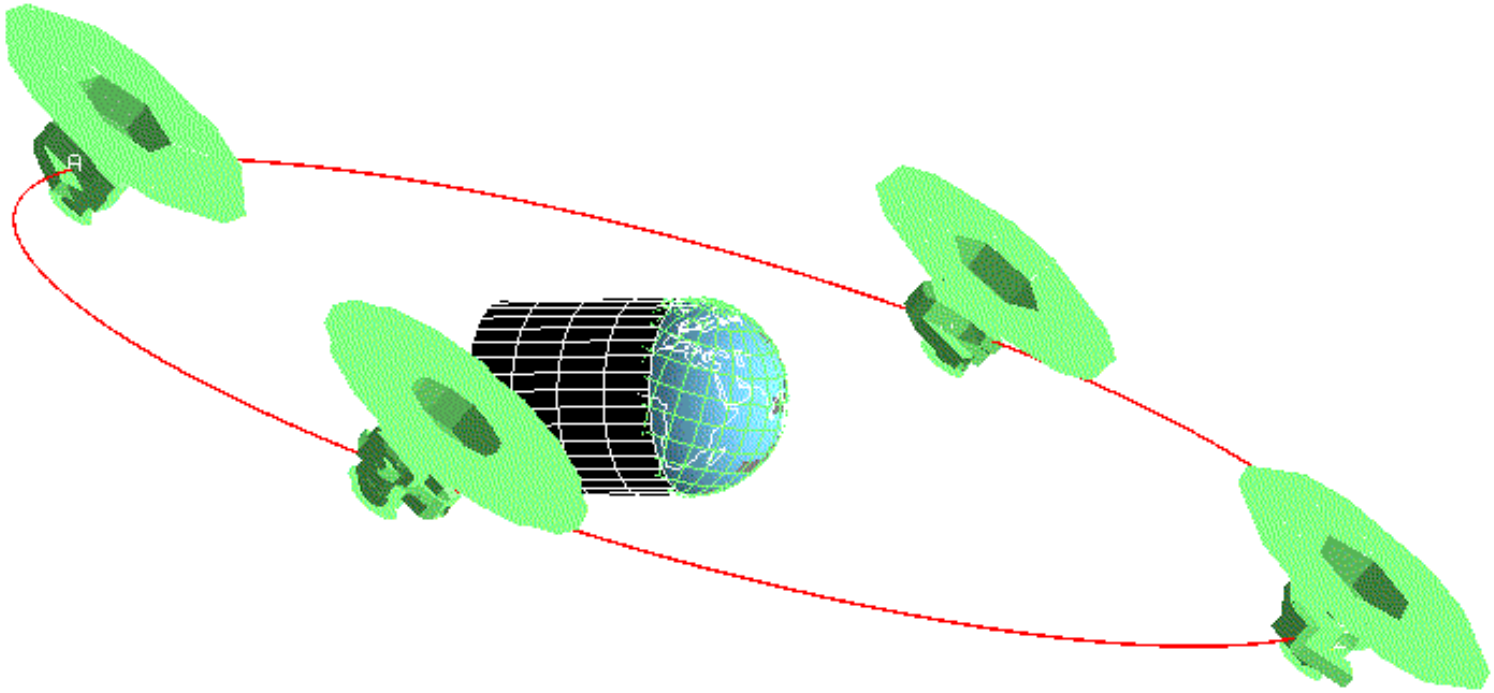
- Account for 40 minute period spin

Full Orbit-

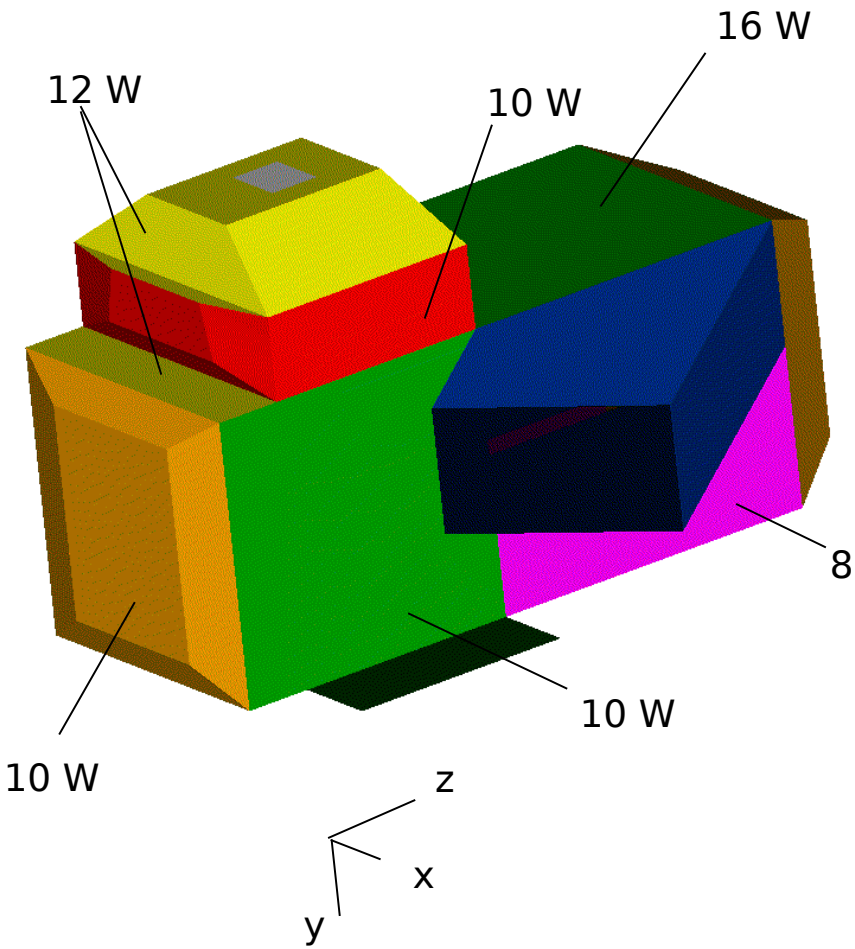
- Account for solar/earth shadowing and eclipse

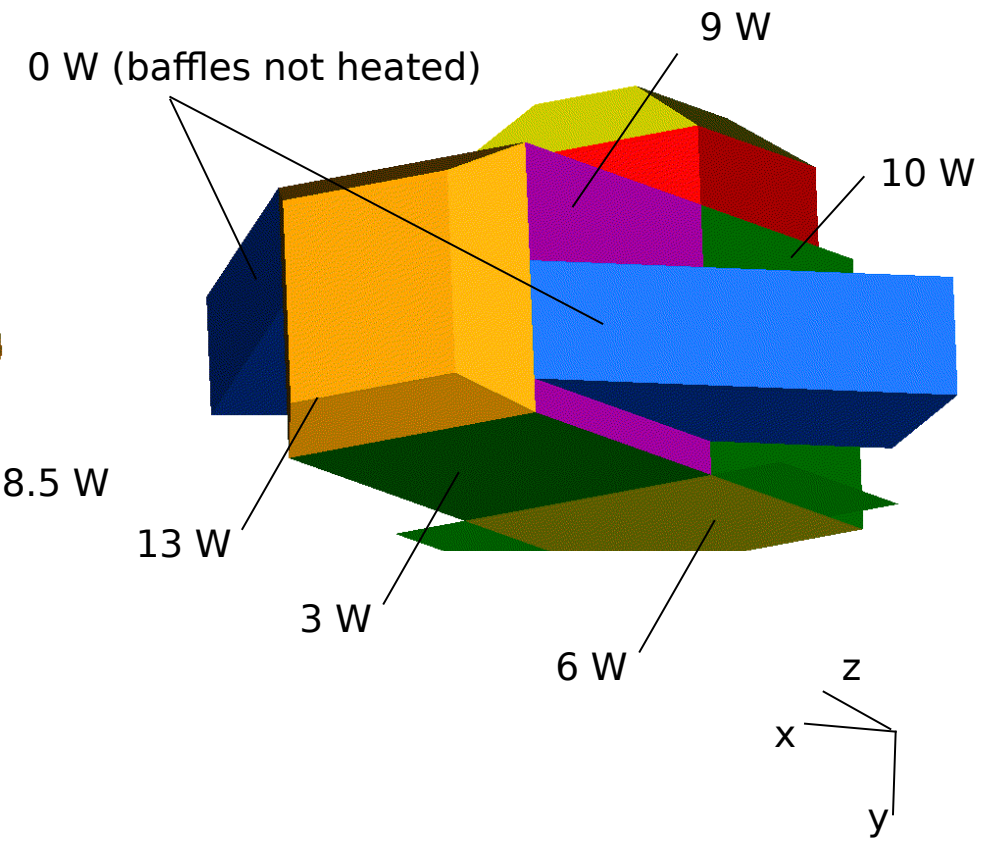
Predicted orbital heating transients will be compared with ‘full’ orbit model

Orbit Heating - Full Model



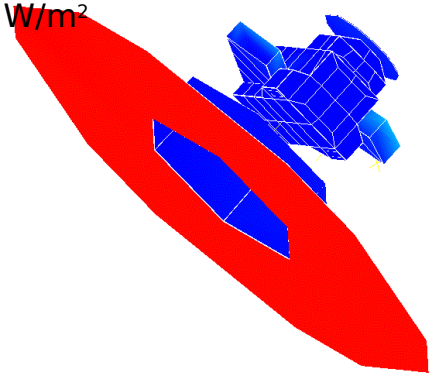
First-Cut Panel Heater Requirements

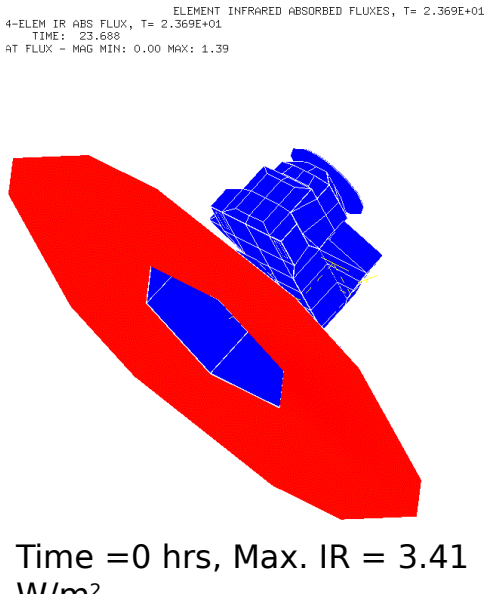


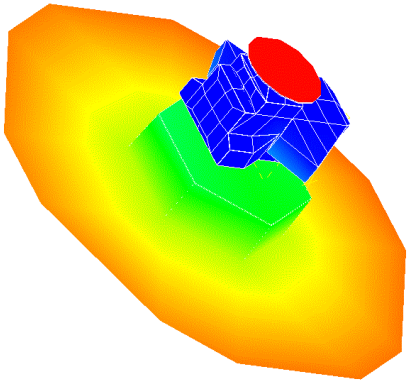


Orbit Heating - Average Absorbed IR, Eclipse Orbit

Time =18 hrs, Max. IR = 2.3 W/m²

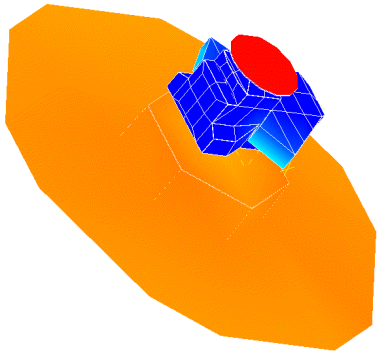






Time=12 hrs, Max. IR = 3.1 W/m²

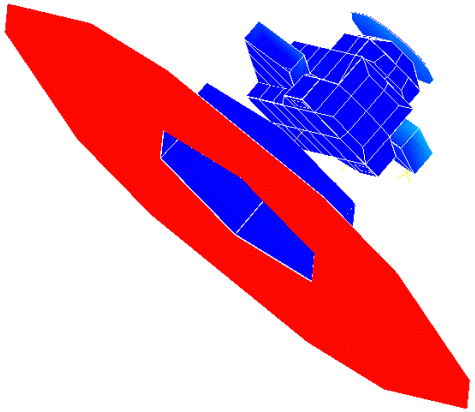
Time =0 hrs, Max. IR = 3.41 W/m²

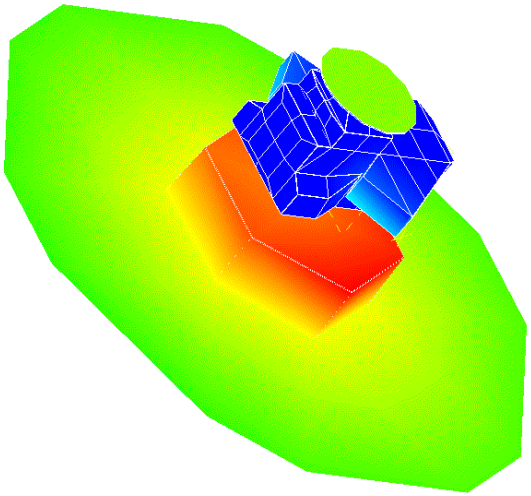


Time=6 hrs, Max. IR = 1.7 W/m²

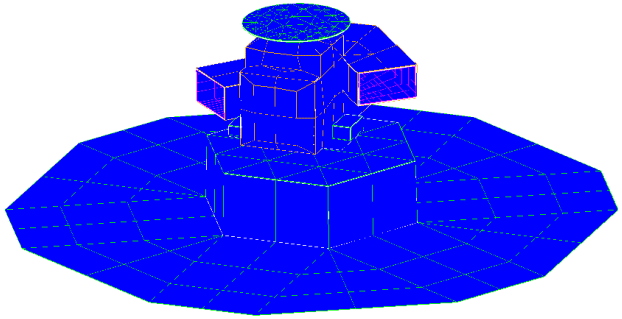
Orbit Heating - Average Absorbed Albedo, Eclipse Orbit

Time = 18 hrs, Max. Albedo = 0.8 W/m²

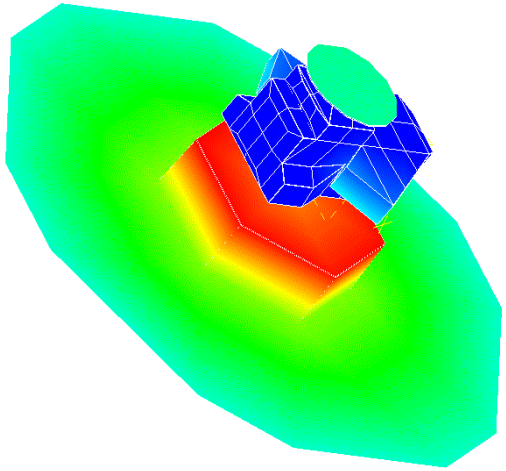




Time = 12 hrs, Max.Albedo = 2.3 W/



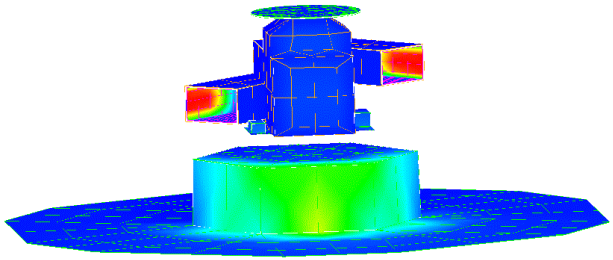
Time = 0 hrs, Max. Albedo = 0 W/m²

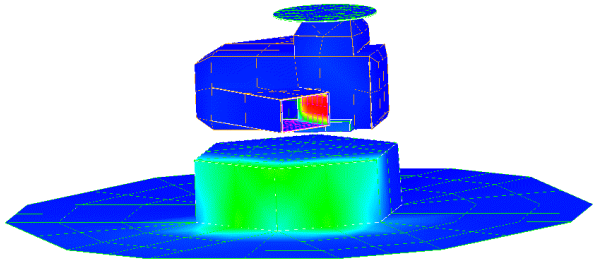


Time = 6 hrs, Max. Albedo = 0.5 W/m²

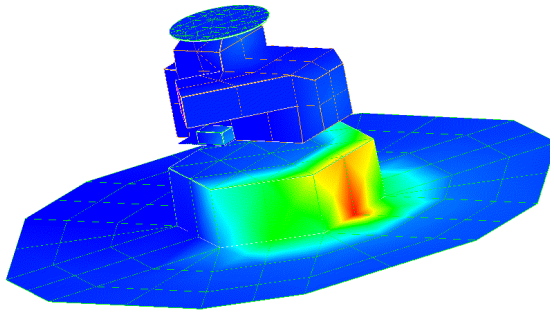
Orbit Heating - Absorbed IR, Single Point in Orbit

Time =30 min, Max. IR = 1.7 W/m²

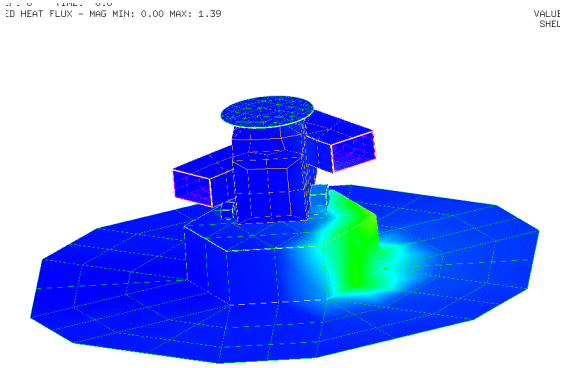




Time=20 min, Max. IR = 2.1 W/m²



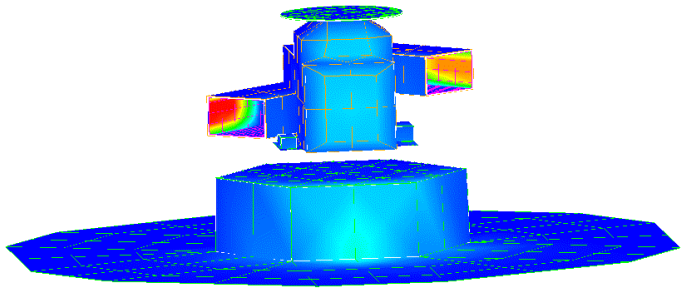
Time =10 min, Max. IR = 1.8 W/m²

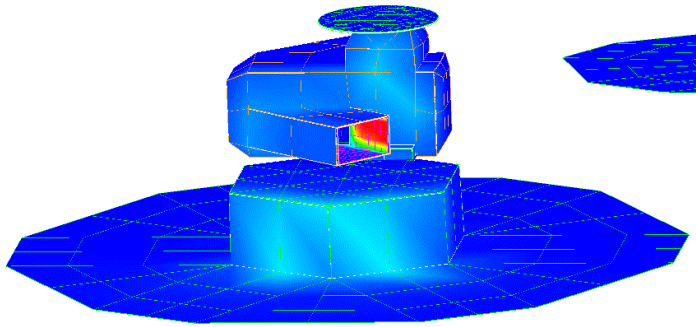


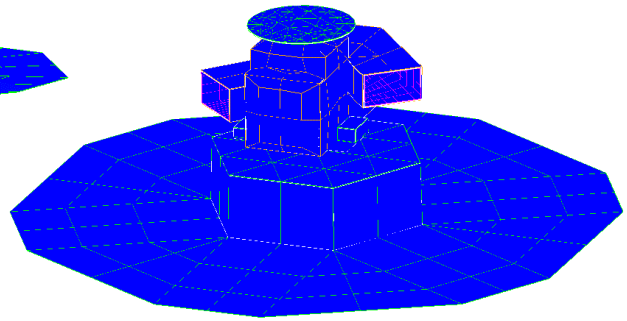
Time = 0 min, Max. IR = 2.15 W/m²

Orbit Heating - Absorbed Albedo, Single Point in Orbit

Time = 30 min, Max. Albedo = 0.5 W/m²

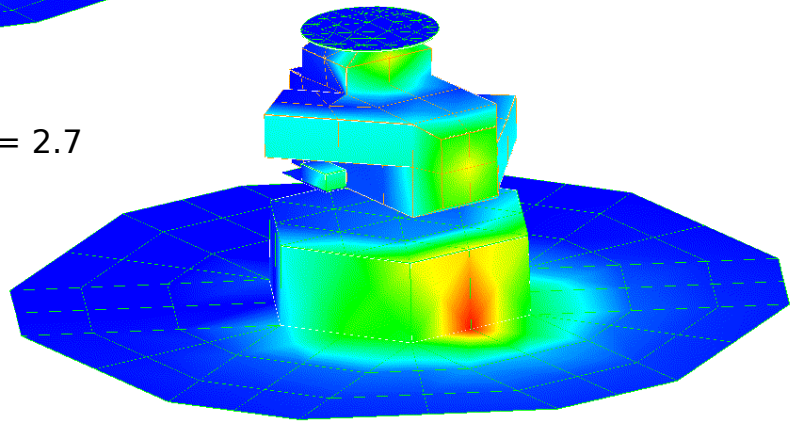






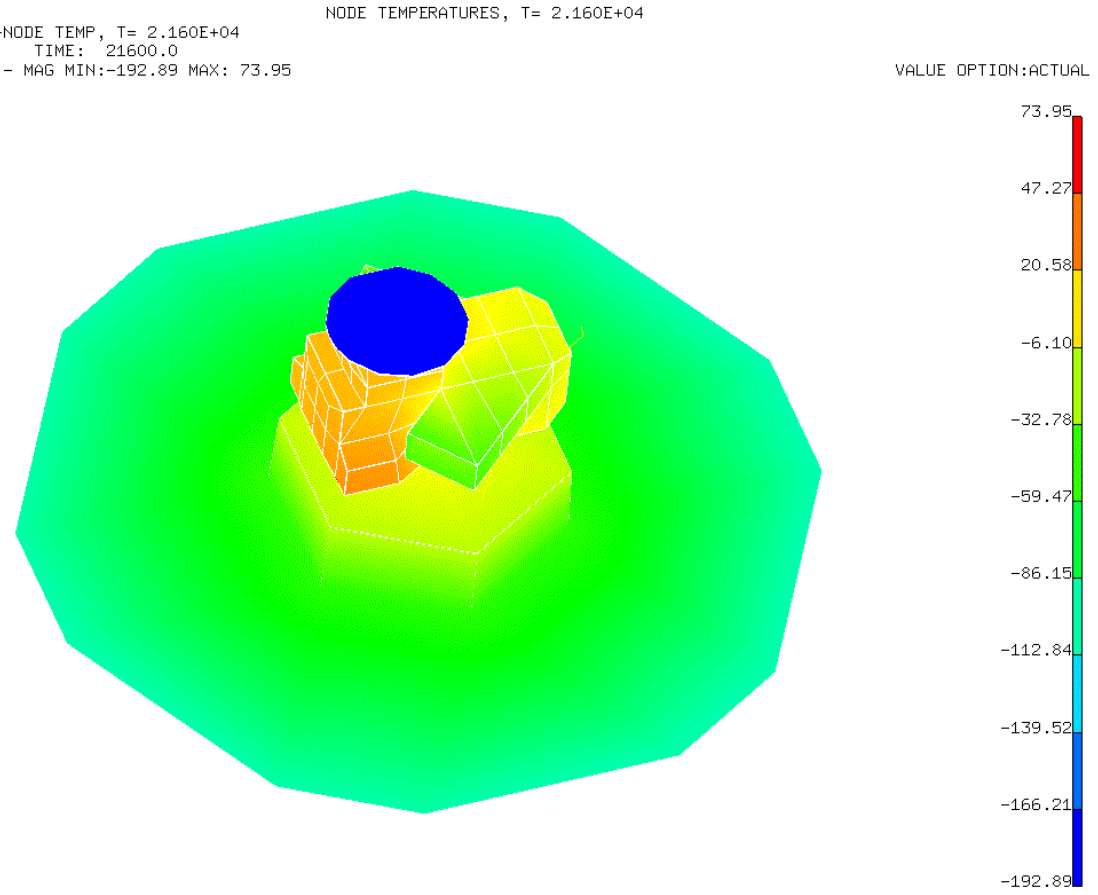
Time = 20 min, Max.Albedo = 2.7 W/m²

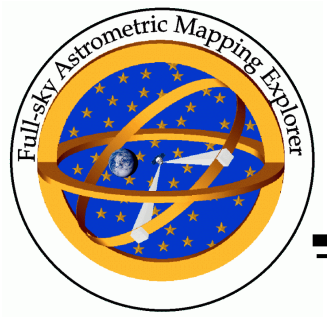
ıe = 0 min, Max. Albedo = 0 m²



Time = 10 min, Max. Albedo = 0.5 W/m²

Quasi-Steady Temperatures Time = 6 hrs





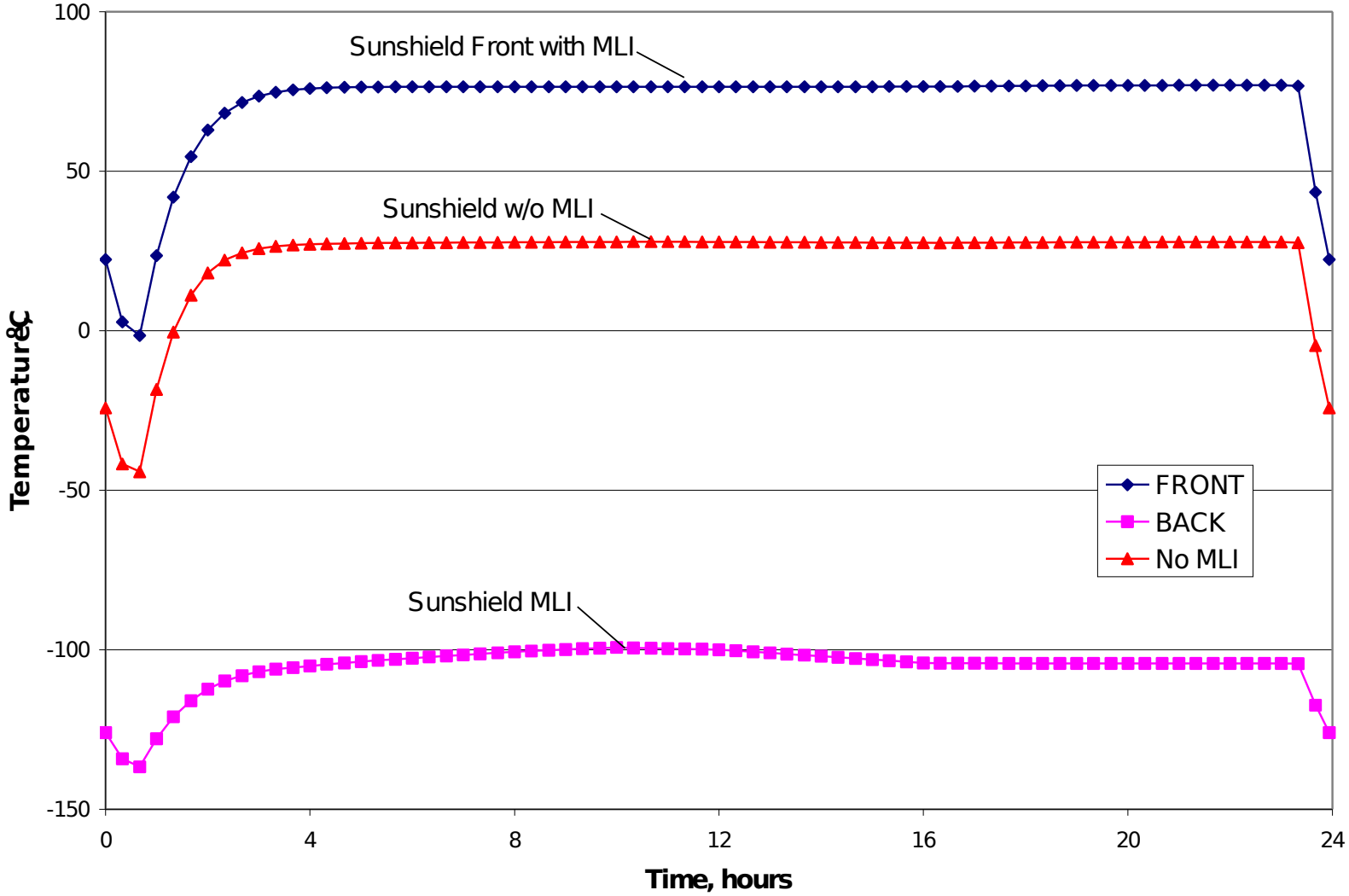
Thermal Design Findings

- Thermal environment investigated using updated instrument configuration
- Calculated heater power requirements are quite similar to those from preliminary thermal model results
- Dissipation of heat from the electronic boxes may be difficult to fully utilize in current configuration - will require additional design study to develop a good solution
- Effect of earthshine and albedo variations are quite small, over a single rotation and a full orbit (without eclipse)
- Mirror temperature gradients found to be extremely stable
- Mirror temperature gradients for highly lightweighted optics are significantly larger than others

Sunshield Blanketing

- Blanketing of sunshield thought to be a more robust thermal design from viewpoint of instrument environment - since sunshield dominates instrument IR loading
- Simplified full-orbit transient model run to investigate effect of sunshield blanket
- Worst-case conditions assumed to be during eclipse orbit
- Thermal gradient change on compound mirror found to approximately double when blanket removed from sunshield
- On the other hand, required instrument heater power approximately 25 W less without sunshield blanket

Average Sunshield Temperatures



Compound Mirror Gradients